**SMART HEADPHONES**

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**CERTIFICATE**

Certified that seminar work entitled “**SMART HEADPHONES**” is a bonafide work carried out in the fourth year by “**PATCHIKORU GIRISH KUMAR**” with Regd.No.**17K61A05F9** in partial fulfillment for the award of Bachelor of Technology in Computer Science and Engineering from SASI Institute of Technology and Engineering during the academic year 2020-2021

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**Abstract**

With the prevalence of smartphones, pedestrians and joggers today often walk or run while listening to music. Since they are deprived of their auditory senses that would have provided important cues to dangers, they are at a much greater risk of being hit by cars or other vehicles. In this paper, we build a wearable system that uses multichannel audio sensors embedded in a headset to help detect and locate cars from their honks, engine, and tire noises, and warn pedestrians of imminent dangers of approaching cars. We demonstrate that using a segmented architecture consisting of headset-mounted audio sensors, a front-end hardware platform that performs signal processing and feature extraction, and machine learning-based classification on a smartphone, we are able to provide early danger detection in real time, from up to 60 m away, and alert the user with low latency and high accuracy. To further reduce power consumption of the battery-powered wearable headset, we implement a custom-designed integrated circuit that is able to compute delays between multiple channels of audio with in power consumption. A regression-based method for sound source localization, angle via polygonal regression, is proposed and used in combination with the IC to improve the granularity and robustness of localization.



1. **Introduction**

Using headphones is quite normal these days, especially for youngsters. They put on headphones not only at home, but also while walking on streets or riding their bicycles.

There have been several studies to prove that using headphones is one of the major causes of road accidents. These incidents seem to be on rise ever since there has been an increase in the use of [noise-cancelling headphones](https://www.hindustantimes.com/tech/jabra-elite-85h-review-a-new-contender-in-the-anc-headphones-space/story-db4mq4d3C66IPj98wgBtlM.html), which cuts off all the background noise. A marquee feature of most of the headphones, noise-canceling hinders the road safety tips.

Finally, there seems to be a solution to the ‘headphone problem’. Researchers have now developed a new kind of headphones, which help in warning pedestrians of the dangers on road.

A [study](https://ieeexplore.ieee.org/abstract/document/8662658) titled ‘Improving Pedestrian Safety in Cities Using Intelligent Wearable Systems’ was published in IEEE Internet of Things Journal in December 2019. The researchers at the Data Science Institute, Columbia, designed an intelligent headphone system. This headphone warns the pedestrians of imminent dangers, like an approaching vehicle

These headphones are said to have miniature microphones and work through intelligent signal processing system, which sends an audio alert to the pedestrian’s headphones. The research team is developing prototypes and is still testing the headphones.

“We are exploring a new area in developing an inexpensive and low-power technology that creates an audio-alert mechanism for pedestrians,” mentioned Fred Jiang, a Data Science Institute member and an assistant professor of electrical engineering at Columbia Engineering.

The pipeline of the headphones includes an ultra-low power, custom-integrated circuit, which uses minimum battery. Additionally, the researchers are using the most advanced data science techniques to design the headset.

1. **Problem**

With the prevalence of smartphones, pedestrians and joggers today often walk or run while listening to music. Since they are deprived of their auditory senses that would have provided important cues to dangers, they are at a much greater risk of being hit by cars or other vehicles.According to a study by injury prevention and CNN, the number of serious injuries and deaths occurring to pedestrians who were walking with headphones has increased. This phenomenon affects cities globally, and is an important societal problem.

1. **Proposed Solution**

To counter this growing public safety concern, researchers at the Data Science Institute, Columbia, are designing an intelligent headphone system that warns pedestrians of imminent dangers.

One solution may come from the pedestrian equivalent of a vehicle collision warning system that aims to detect nearby vehicles based purely on sound. The intelligent headphone system uses machine learning algorithms to interpret sounds and alert pedestrians to the location of vehicles up to 60 meters away.

PAWS, Pedestrian Audio Wearable System is a wearable headset platform and Smartphone application that uses five microphones and a set of machine learning classifiers to detect, identify, and localize approaching cars in real time and alerts the user using audio/visual feedback through a Smartphone.

Beyond ordinary pedestrians, police officers performing a traffic stop on a busy road or construction workers wearing ear protection might also benefit from such technology, Jiang says. The PAWS project has already received US $1.3 million from the [National Science Foundation](https://www.nsf.gov/), and the team has an eye on eventually handing a more refined version of the technology over to a company to commercialize it.

1. **Working**

The system consists of three main components:

1.Five MEMS microphones.

2. Front-end hardware for multichannel audio feature extraction.

3.A Smartphone host for machine learning-based vehicle detection and localization

* 1. **Five MEMS microphones:**
     1. **MEMS microphone:**

The MEMS (MicroElectrical-Mechanical System) microphone is also called a microphone chip or silicon microphone. A pressure-sensitive diaphragm is etched directly into a silicon wafer by MEMS processing techniques, and is usually accompanied with integrated preamplifier.

The ASIC inside a MEMS microphoneuses a charge pump to place a fixed charge on the microphone membrane. The ASIC then measures the voltage variations caused when the capacitance between the membrane and the fixed backplate changes due to the motion of the membrane in response to sound waves

**4.1.2 Usage of Five MEMS microphones:**

Four of the MEMS microphones, labeled MIC1 to MIC4, are distributed over the user, at the left and right ear, back of the head, and in front of the user, to provide relevant information about the sound source’s location.

These micro phones work through intelligent signal processing system, which sends an audio alert to the pedestrian’s headphones.

The standard microphone of the headset (the fifth micro-phone, MIC5) is connected to the 3.5-mm audio input of the phone. Data from the fifth microphone is directly acquired by the smartphone.

* 1. **Front-end hardware for multichannel audio feature extraction:**

The wearable warning system’s main hardware is designed to fit inside the left ear housing of commercial headphones and draws power from a rechargeable lithium-ion battery. A custom integrated circuit saves on power by only extracting the most relevant sound features from the captured audio and transmitting that information to a paired smartphone app.

The front-end hardware acquires signals from these microphones and locally extracts acoustic features that are used by a Smartphone application.

Using the features computed by the front-end hardware and an audio stream from the headset microphone as inputs, machine learning classifiers running inside the PAWS application detects the presence of an approaching vehicle and estimates its position relative to the user.

* 1. **Smartphone host for machine learning-based vehicle detection and localization:**

• The Smartphone uses acoustic features received from the embedded front-end system to estimate the distance and direction of the car.

• The MCU must sample the data from the four MEMS microphones and perform feature extraction, while the BLE module is responsible for transferring the calculated features to the Smartphone.

The smartphone hosts the machine learning algorithms that were trained on audio from 60 different types of vehicles in a variety of environments: a street adjacent to a university campus and residential area, the side of a windy highway during hurricane season, and the busy streets of Manhattan.

However, relying purely on sound to detect vehicles has proven tricky. For one thing, the system tends to focus on localizing the loudest vehicle, which may not be the vehicle closest to the pedestrian.The system also still has trouble locating multiple vehicles or even estimating how many vehicles are present.

**5.Power Consumption and Price Breakdown**

* We evaluate the energy consumption of PAWS low-energy by measuring the power consumptions for both the embedded platform and the smart phone.
* The overall power consumption of the system is below 70mA, allowing for 17 h of continuous operation when powered by 3 AAA Alkaline batteries.
* The entire setup will be released for less cost.

**6.Advantages**

* Inexpensive
* Low Battery Usage
* Reduces Pedestrian Accidents
* Provides Safety

**7.Disadvantages**

* This system cannot identify the presence of multiple number of cars.
* **Covered Microphones:** If the microphones are covered then PAWS would be rendered ineffective.
* **Noisy Streets:** Streets may contain different types of noise, so the system should be well trained with as many scenarios as possible.

**8.Results**

* PAWS is able to identify honks and tire/engine sounds with nearly 100% precision across all tested environments.
* It further provides feedback on the direction of the sound source with 80%–98.5% accuracy
* Predicts the distance from the user with 78% accuracy.

**9.Conclusion**

* As technology evolves , new dangers surround modern cities. So innovative safety solutions must arise to uphold the welfare of common citizens.
* With the help of this Smart Headphones , we can provide solution to twalking**.**

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